Vol. X. JULY, 1893. No. 3.

THE AMERICAN METEOROLOGICAL JOURNAL.

A MONTHLY REVIEW OF METEOROLOGY.

TABLE OF CONTENTS.

BOSTON, NEW YORK, CHICAGO, AND LONDON.

GINN & COMPANY,

Publication Office, 7-13 Tremont Place, Boston, Mass., U.S.A.

SINGLE COPIES . . . 30 cents. | *PER ANNUM $3.00*

Entered at the Post-office, Boston, as second-class mail matter.

THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. X. BOSTON, MASS., JULY, 1893. No. 3.

RECENT FOREIGN STUDIES OF THUNDERSTORMS: II. GERMANY.

R. DEC. WARD.

IN this JOURNAL, Vol. II., 1885-6, pages 496-499, Vol. III., 1886-7, pages 40-42, Prof. Davis gave a summary of the principal publications on the thunderstorms of Central Germany and of Bavaria down to 1886. The present paper takes up the subject at that date and brings it down to the close of 1892. As in the previous paper of this series, on the Thunderstorms of Great Britain (see this JOURNAL, Vol. IX., 532-541), the Signal Service Bibliography on *Storms* has been referred to for the titles of publications issued from 1886 to 1889. Many of the articles have not been accessible in the original, and in giving the summaries of these the reviews published in the Austrian *Zeitschrift für Meteorologie* have been used. In preparing the bibliography from 1889 to 1892, given at the end of this article, the *Zeitschrift* has also been referred to. For the sake of simplicity the subject of this summary has been divided into two divisions corresponding to the different districts of Germany (Southern, and Central and Northern Germany), with a special heading for general publications, and with some brief comments at the end on the whole body of material.

Southern Germany: Bavaria, Wurtemberg, and Baden. — The study of thunderstorms in Bavaria, Wurtemberg, and Baden has been systematically carried on since 1879, under the direction of Prof. Wilhelm von Bezold and of Dr. Carl Lang, and the results have been published in the volumes of the "Beobachtungen der Meteorologischen Stationen im Koenigreich Bayern,"

from year to year (Vols. IX.–XIII.). From the abundant material presented in these reports we can extract only a few of the most important facts. The study of the records from 1879 to 1890 [*Met. Zeitschrift*, VIII., 1891 (68)] gives some interesting results. The mean velocity for these years is 34.5 kilometers (kilometer = $\frac{5}{8}$ mile) an hour, and there is a decided increase in velocity from 1879 to 1884–5, followed by a decrease. This is found to be connected with the shifting of the paths followed by the cyclones of Europe from year to year, and probably further with sunspot cycles. The maximum of sunspots about 1885 was followed by a maximum velocity of thunderstorms, and in 1889 the minimum of sunspots by a minimum velocity of thunderstorms. The velocity of thunderstorms is greatest in winter, decreasing towards summer, with a minimum in May and June. The average rate of movement for March to September is 35.9 kms. an hour; for October to January, 55. kms. The months of greatest frequency are June and July. Thunderstorms vary in velocity according to the directions from which they come. During the years 1880–89 thunderstorms from N.N.E.–E. had a velocity of 25 kms.; from E.S.E.–S. 26.5 kms.; from S.S.W.–W., 38.6 kms.; and from W.N.W.–N., 32 kms. In other words, the storms from the east have a velocity of 25.7 kms.; those from the west, 37 kms. A tabulation of the thunderstorms in zones, according to degrees of latitude, shows that those moving from north to south are retarded as they approach the Alps, and, further, that the more extended a district the thunderstorm covers, the faster it moves. The hours of greatest frequency are 3 to 4 P. M., with a second maximum 2 to 3 A. M.

Certain of the individual years show interesting peculiarities. In 1889, 699 progressive thunderstorms were noted; in 1890, 749, and only those were considered which were represented by three isobronts, *i. e.*, which lasted at least one hour. The year 1889 showed that thunderstorms circle around the primary depressions according to Buys-Ballot's law. On June 2, 13, and 23 this was especially well illustrated, for a large series of thunderstorms was developed around a cyclonic centre and moved around it in the spiral path of the winds, those on the southern side coming from the west, while those on the eastern side came from the south, etc. The velocity of these storms

increases as the distance from the cyclonic centre decreases. 1890 was abnormal in showing an increase in the velocity of storms moving from north to south, instead of the decrease usually noted and already referred to. The 1882–86 records (*Met. Zeitschrift*, IV., 1887, 233) give an hourly velocity of 41 kms. This corresponds exactly to tne velocity in France, but is less than the velocity in Norway and in Italy. The maximum diurnal velocity comes in the late night and early morning hours, and a second maximum between 1 and 3 P. M. The minima are in the later morning and afternoon hours.

With regard to hail, it appears from the results of the years 1882–1887 [*Met. Zeitschr.*, VI., 1889 (17)], that hail falls most frequently between 3 and 6 P. M., and that rivers, lakes, and forests are no protection against damage by hail. Winter thunderstorms are more often accompanied by hail (frozen rain ?) than summer thunderstorms [*Met. Zeitschr.*, VIII., 1891 (74)]. While during August one storm in every twenty-five is accompanied by hail, in January one in every four or five brings hail (frozen rain?). This is probably due to the fact that in summer the hail usually melts before it reaches the ground. Hail does not fall without electrical discharges (*Met. Zeitschr.*, VI., 1889, 271).

By grouping the records from Bavaria and Wurtemberg for the years 1880–1887, von Bezold found a periodicity of thunderstorms in 25.84 days (*Ueber eine nahezu 26-taegige Periodicitaet der Gewitter Erscheinungen.* Sitzungsberichte der K. Preuss. Akad. zu Berlin, XXXVI., 1888, 905; *Met. Zeitschr.*, V., 1888, 85). This periodicity may be connected with differences in the amount of radiant energy emitted by different parts of the sun.

Central and Northern Germany. — One of the facts clearly brought out in the thunderstorm observations carried on during recent years in Germany, under the direction of von Bezold, Assmann, and others, is a second maximum of occurrence in the early morning hours. This feature is made the subject of an article by Dr. Assmann (*Met. Zeitschr.*, II., 1885, 433–445). It appears from a study of the records that, in central and northern Europe, winter thunderstorms always occur in connection with the larger cyclonic storms, and generally during the night; they often cross extended areas with considerable velocity, but more often appear singly or in interrupted succession,

and over smaller areas than most of the summer thunderstorms. The winter thunderstorms are of short duration, but their lightning is more destructive than that of summer storms, owing to the low altitude of the clouds. The former occurring in connection with cyclonic storms, it is but natural to expect that they will be most frequent when the cyclonic storms are the most violent, and that is at night, as the records of the daily period of wind velocity clearly show. The winter night maximum is also quite well marked in the records of Russia, Holland, Scandinavia, Scotland, and Iceland. It is to be noted that these winter thunderstorms are much more frequent in northern than in southern Germany.

With regard to the classification into cyclonic (*wirbel*) and heat (*waerme*) thunderstorms, Dr. Hellmann points out that the dividing line between the two is very difficult to determine, for heat thunderstorms, so far as known, are always connected with secondary cyclonic depressions.

The systematic observation of thunderstorms in Saxony has brought out a large number of interesting facts. The "Jahrbuch" of the Saxon Meteorological Institute for 1884 contains the results of the investigation for that year (*Met. Zeitschr.*, III., 1886, 131). The storms for the year were charted on first thunder lines, or isobronts, and a study of these charts reveals the fact that there are usually centres, or nests, from which the individual storms seem to move out, just like the small ripples or waves produced by throwing a stone into a body of water. No movement of a distinct thunderstorm from one end of the district to the other can be determined for this year, but the thunderstorm nests themselves seem to grow and spread, changing their form, and finally contracting again, until the storms cease. These thunderstorm nests seem to be confined to certain districts, and to remain in about the same place throughout the time during which the thunderstorms prevail, increasing in size as the activity of the storms increases, and decreasing in size towards the hours when the thunderstorms weaken and dissipate. A further report on the thunderstorms of 1887 has been made by Dr. Oskar Birkner [*Spezieller Bericht ueber die Forschungen bezueglich der Gewitter- und Hagelerscheinungen waehrend des Jahres* 1887. Jahrbuch des saechsischen Meteorologischen Instituts. Anhang 5. *Met. Zeitschr.*, VI., 1889

(88)]. Certain districts of Saxony seem to be more subject to thunderstorms than others, *e. g.*, in 1885–87 some parts of Saxon Switzerland were more frequented by thunderstorms than other parts of the kingdom. The following table shows the distribution of thunderstorm reports by hours :—

Hour.	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
A. M.	80	79	42	32	51	74	67	42	59	67	200	345
P. M.	483	666	704	813	611	486	316	233	223	165	103	82

The maximum is clearly seen to be from 3 to 4 P. M., with another secondary maximum between 5 and 6 A. M. The thunderstorms in Saxony last longer at higher altitudes than at lower levels, which seems to show that mountains delay their advance. The mean duration of the storms at different heights above sea level is shown in the following table :—

Heights in meters.	100-200	200-300	300-400	400-500	500-700	More than 700
Number of reports . . .	363	338	356	102	140	160
Mean duration in minutes,	58	74	77	85	86	89

The large thunderstorms seem to be made up of a large number of smaller storms, which may unite, cross each other's path, or divide ; they develop over narrow districts, on the advance edge of a cyclonic area, forming nests, and are most severe in the district nearest the centre of the cyclone. In 1887, 220 lightning strokes which reached buildings were noted, and of these 65, or 29.5 per cent caused fires. May is the month of most frequent hail, the hours of maximum frequency of hail occurrence being 2 to 4 P. M.

One of the features most frequently noted in all countries where thunderstorms have been observed, is the apparent effect of topography upon their movements. In this connection the study of the thunderstorms of July 13–17, 1884, by Dr. Richard Boernstein, brings out some facts of interest (*Die Gewitter vom* 13–17 *Juli*, 1884, *in Deutschland. Met. Zeitschr.*, IV., 1887, 443). The storms of these days came in connection with cyclonic areas to the west and southwest of Ireland, with secondary depressions over Europe, the latter starting from the south-eastern side of the primary centre and moving in an easterly direction. Owing to the strong contrasts in temperature between the warm winds from the east and south and the cold winds from

the north, the conditions were very favorable for thunderstorm development. The charts of the storms of these days show a movement from southwest and west, and a rate of 25-45 kilometers an hour. The influence of mountains and rivers on the course of the storms was marked, the former usually hastening the velocity of the storms as they approached, and lessening their rate as they departed, while the rivers seemed to act as hindrances. Thunderstorms are frequently stopped entirely or partly on reaching a large river, and in cases where the river is crossed, the thunderstorm is noted as breaking out on both sides of the river at once. When a thunderstorm is delayed in one portion of its front by a mountain or river, the portions which are not thus delayed continue to move forward, and having passed beyond the obstruction, extend out sideways in such a way that in a short time the storm front is again unbroken. The explanation of these features is suggested as follows: a thunderstorm is due to the ascent of a mass of air, which rises in a narrow band, coinciding with the thunderstorm front, and moving at right angles to the latter. Towards the bottom of this ascending mass of air there is an indraught of air from front and rear. Now if, for any reason, the inflow is checked on one side, the inflow from the other side pushes the whole mass of ascending air towards the obstruction. The movement of thunderstorms is dependent on the general movement of the atmosphere, which is aided by this inflow. When a thunderstorm is approaching a mountain range, the inflow of air from in front is largely checked, and, therefore, the inflow from the rear tends to push the storm along faster than before. On the other hand, when the thunderstorm is leaving the mountains, the reverse takes place, and the inflow from the front tends to retard the advance of the storm. The influence of rivers is thus explained: rivers being cooler than their surroundings in summer, are regions of descending currents of air, while on the banks the air is ascending. So when a thunderstorm reaches a stream it is either stopped entirely, or else it rises over the obstruction, and coming within the influence of the ascending current on the other side, is drawn down again, thus giving rise to the simultaneous outbreak on both sides of the river, which has been so often noted.

The effect of topography is brought out in several other cases also. The town of Beesenlaublingen, in the valley of the Saale,

for instance, is reported as having much less rainfall than other places in its neighborhood.* It is situated in a valley, and all thunderstorms coming to it from the west either follow along one side of the valley or divide and follow both sides, leaving the town free from rainfall unless the storm is sufficiently extended to reach across from one side of the valley to the other. Thunderstorms coming from the east usually give precipitation at Beesenlaublingen, but they are seldom noted. The thunderstorms of June 1, 1886 (Hugo Meyer, *Die Gewitter des oberen Leinethales am 1 Juni, 1886, Met Zeitschr.*, III., 1886, 345) showed a marked decrease in velocity as they crossed over a range of hills in their course, the rate of advance being reduced one half. The dividing of a thunderstorm on coming to a mountain is noted in connection with the storms at the Schneekoppe (1599 meters) in the Riesengebirge (Eugen Reimann, *Einiges ueber Gewittererscheinungen im Riesengebirge, insbesondere auf der Schneekoppe, Met. Zeitschr.*, III., 1886, 249). It appears from many observations made at this station that most of the thunderstorms which come from the west turn off at the mountain to one side or the other. Many divide, but usually come together again after passing the mountain. This fact has a marked effect on the amount of damage done by thunderstorms in places lying in the lee of the mountain as compared with that done in places not in the lee of the mountain, the damage in the former case being much less than in the latter. Most of the thunderstorms observed at the Schneekoppe are below the summit. Of the average number of eighteen storms a year, about ten are below the summit, five or six cover the summit, and two or three rise above it. When the storms are below the level of the summit the sky overhead is either entirely cloudless, or else there are a few clouds of different kinds. Observers on the summit have several times noted lightning flashes coming from lower-lying thunderstorm clouds and going up into the clear sky above.

A further report on the thunderstorms of the Schneekoppe from 1859 to 1886 (Eugen Reimann, *Weitere Berichte ueber Gewittererscheinungen im Schlesischen Gebirge, Met. Zeitschr.*, IV., 1887, 164) shows the periods of maximum frequency to be

* See Bibliography at the end of this article, Article No. 1.

the beginning of June and the beginning of July. There is also further testimony as to the occurrence of thunderstorms below the summit, and of lightning darting from the clouds into the clear sky above When thunderstorms have been observed below the summit, the cirrus overflow has never been seen ; it appears, therefore, that cirrus clouds are not essential to thunderstorm development in this case.

A report by Dr. A. Krebs, based on the thunderstorm observations made at Hamburg from 1878 to 1887, in connection with records of self-registering apparatus at one station and with a study of the daily synoptic weather maps, deals with a number of the main features of thunderstorms (*Beitraege zur Kenntniss und Erklaerung der Gewittererscheinungen auf Grund der Aufzeichnungen ueber die Gewitter Hamburgs in den Jahren* 1878 *bis* 1887, Stuttgart, 1889; reviewed in *Met. Zeitschr.*, VI., 1889, 57). The changes of temperature accompanying thunderstorms, usually noted as a fall in temperature by day and a rise at night, are not ascribed by the author to the rain, for these changes occur in thunderstorms which give no precipitation, and often occur before the rain. Further, the liberation of latent heat due to the condensation should give a rise of temperature by day as well as by night. These changes are referred entirely to the effect of the clouds, which during the day cut off insolation, and during the night prevent radiation, thus causing the observed cooling and warming. All thunderstorms, the author believes, are formed from the mechanical combination, or influence (*einwirkung*) of at least two depressions ; the place of their development is where these depressions have the greatest influence on one another, that is, between them, in a region of higher pressure; *heat* thunderstorms are due to the influence of two or more local depressions on one another, and *cyclonic* thunderstorms are due to the influence of one primary depression on one or more of its forerunners (*auslaeufer*). The increase in relative humidity during thunderstorms by day is ascribed to the sudden fall in temperature. The form of a thunderstorm is that of a narrow band, the wind direction depending on the direction in which the depressions lie, and on the general atmospheric movement, which is determined by the primary depression. The shift of wind which comes shortly before or shortly after the rain is due to the succession of several depressions,

and the low temperature observed in thunder-clouds, where we should expect high temperature owing to the condensation, is explained on the supposition that there is a change of heat into electricity. Cirrus clouds are not believed to form over ascending masses of air.

The observations made at Goettingen from 1857 to 1880 have been reduced by Dr. Hugo Meyer (*Beitraege zur Kenntniss der Gewitterperioden, Met. Zeitschr.*, V., 1888, 85). There are two maxima of occurrence, one early in July and the other about the middle of August. The thunderstorm maxima come later in the year in western Europe than in the eastern districts. The Goettingen results show two other maxima, one in April (1–10), and the other in the fall (Sept. 28–Oct. 7), and diurnal maxima at the usual afternoon and night hours. The summer maxima come some hours later than those of the winter, and in winter the afternoon maximum is divided into two maxima. This latter phenomenon is explained as follows: heat thunderstorms occur when there is the most active ascent of warm air, and this occurs earlier in winter than in summer. Cyclonic thunderstorms occur when the cyclones are most active, and this is a little later in winter than in summer. From this it is seen that winter thunderstorms of the first maximum are regarded as heat thunderstorms, and those of the second maximum as cyclonic thunderstorms. An examination of the periods of thunderstorm occurrence and of the moon's phases shows that the thunderstorms are least frequent at the time of full moon, and most frequent at the time of new moon and first quarter, although the difference is but slight. Dr. Koeppen has further examined the records from Prag and Gotha, together with those of Goettingen just referred to, in connection with the phases of the moon, and finds that the results bear out those for the rest of Germany in showing a greater frequency of thunderstorms at new moon and at first quarter (*Mondphasen und Gewitter, Met. Zeitschr.*, V., 1888, 114). The excess at these times is, however, so slight that it can be of no use in forecasting.

The thunderstorms of Lippe (*Die Gewitter des Jahres* 1891, *nach den Beobachtungen in den Fuerstlich Lippischen Oberforstereien, Das Wetter*, IX., 1892, 116), during 1891 show the following results :—

Hours of Frequency.	Per cent.
12-6 A. M.	7.
6-12 "	13.6
12-6 P. M.	55.7
6-12 "	23.7

The average duration of all the thunderstorms was forty-nine minutes, twelve seconds. June had the longest storms, averaging one hour, two minutes. 33.9 per cent moved from west to east; 38.2 per cent from southwest to northeast.

The observation of thunderstorm clouds has brought out some noteworthy points. Dr. Kassner has, in several storms, noted the occurrence of small grayish-yellow clouds beneath the real thunder-clouds, which move as far as the zenith, where their edges dissolve, the rain following immediately.* These small clouds have two or three times the velocity of the other clouds, are at a less altitude, and look like loose masses of cotton wool. Their great velocity shows that there is a strong current of air somewhat beneath the thunder-clouds, this current being noted at the earth's surface as the squall wind. In one storm these clouds were noted as constantly changing their form, and their tops were turned backwards. The latter point indicates that there are two currents of air, the one below the stronger, and the one above the weaker, and that these clouds are on the dividing line between the two. These clouds, the author thinks, may perhaps be regarded as the real "electrical" or thunder-clouds. One thunderstorm which had exceptionally bright and frequent lightning had also very remarkable "electrical" clouds of this kind.

General. — Prof. von Bezold, who has given much study in recent years to the subject of thunderstorms, has lately published a series of four papers on the "Thermodynamics of the Atmosphere." The first three of these have been translated into English by Prof. Cleveland Abbe, and the translations published in the *Smithsonian Miscellaneous Collections* (Washington, 1891), under the title of "The Mechanics of the Earth's Atmosphere." The papers were originally published in the *Sitzungsberichte der König. Preuss. Akademie der Wissenschaften zu Berlin.* The fourth paper of the series deals with the super-

* See Article No. 3 in the Bibliography.

saturation and over-cooling of the atmosphere in relation to the phenomena of thunderstorms. (Reprinted in *Met. Zeitschr.*, IX., 1892, 321, *Das Wetter*, IX., 1892, 233, 254, 278.) The writer's idea is, in brief, that under certain conditions the atmosphere may contain a greater amount of vapor than is, under the usual conditions, possible at its temperature, *i. e.*, it may be supersaturated, and that the sudden removal or annulment of this condition may be the cause of the sudden heavy rainfalls known as cloud-bursts. Further, it is well known that clouds consisting of water globules and which do not contain ice particles may occur at temperatures much below freezing, and that when such globules touch solid bodies they at once become ice. The cessation of these conditions of over-cooling or of supersaturation must have, as a consequence, a sudden liberation of latent heat, an expansion of the air, a sudden rise of pressure and a succeeding fall, which are phenomena that regularly accompany thunderstorms. Supersaturation may result from adiabatic expansion, and von Bezold shows that if the ascending mass of air pass the line of saturation by only a very little it must bring about a condition of supersaturation whose cessation would be sufficient to cause such rises of pressure as are commonly observed in thunderstorms. Although supersaturation in free air has never been observed or experimentally proved, the fact of over-cooling in clouds rests on good evidence. In such a condition, when the water in the clouds is suddenly changed into ice, latent heat is liberated and a rise in temperature follows.

Von Bezold thinks that heat thunderstorms and cyclonic thunderstorms are really in their typical development very different, although they are confused by most writers, and he defines them as follows : —

Cyclonic thunderstorms accompany the central parts of deep well-developed depressions ; they are phenomena of rapidly ascending currents of air, such as are found in cyclones ; they occur in dull, unsettled weather and especially near the paths of the barometric minima, and where the latter are most marked, *i. e.*, along the coasts. These thunderstorms have a horizontal cyclonic movement of winds around them. Their annual and diurnal periods are the same as those of the cyclones, and their cause is the same as that of cyclones.

Heat thunderstorms, on the other hand, are the result of the warming and consequent instability of the lower air. They need for their development moist, quiet air, without marked cyclonic or anti-cyclonic movement, and strong insolation. They occur, therefore, between cyclones and anti-cyclones, where there are neither strong ascending nor descending currents, and not at the centres of either. The regions of occurrence constitute secondary, often hardly perceptible, cyclones, shallow troughs between two regions of higher pressure, and ridges or tongues of high pressure between two depressions, especially if the latter are shallow and extended. According to this view, the depressions are of secondary importance, while the ridges and tongues of high pressure and the advancing high pressure necessary to the formation of secondaries, are the essentials. The warming of the lower air can be best accomplished when the air is nearly calm, when the ground is dark-colored, and when surrounding higher ground prevents the air from moving off to one side or the other. It is for this reason that low marshy places are often found to be the thunderstorm nests. Further, in summer, at a given moment, places in a general N.N.W.-S.S.E. line have been exposed to insolation the same length of time, and therefore it is natural that a simultaneous condition of instability should occur along this line. The result is that at single centres, arranged in a row, where there are some especially favorable peculiarities, the lower unstable air breaks through the overlying air and rises, developing a thunderstorm.

Precipitation usually begins at heights where the temperature is below freezing, and therefore it is usually hail at the start, which melts on the way down, causing a fall in temperature. This produces a nearer approach of the isobaric surfaces in the region of precipitation. In front of the storm the air has been rising, and aloft it has flowed off towards the cooled side, increasing the pressure there. From the front of the storm the squall-wind rushes out, causing the air in front, which is already liable to overturn, to ascend. In this way if the original warming was sufficient, the storm continues to move across country as a narrow band, the wind blowing at right angles to the isobars. These thunderstorms, moving with definite fronts across country, are the typical heat thunderstorms, and may be

described as rotating around a horizontal axis. Besides these typical thunderstorms there are others which occur sporadically, and these have been described as "erratic thunderstorms" (Fron). These do not have a distinct front ; are often single whirls with vertical or inclined axes, and are therefore of a nature between heat and cyclonic thunderstorms, though usually of the latter kind.

Von Bezold sums up his paper in the main as follows: when the mass of warm air rises, if there are enough centres of condensation (*nebelkerne*), condensation must begin as soon as the dew point is reached, but precipitation does not necessarily follow at once, for the whole mass may be carried far above the level of the dew point by the strong ascending velocity; the liberation of latent heat resulting from condensation may not only counteract further cooling by expansion, but may even warm the air. Again, as has been stated, the water particles of the clouds may be carried far above the level of freezing, and as soon as this overcooled water suddenly freezes, warming follows at once, which warming must make itself felt as a rise of pressure and be followed by an increase of energy. The liberation of the latent heat inside the cloud explains the sudden expansion of the latter into the so-called "thunder-heads," and also the other movements of thunder-clouds, which it does not seem possible to explain as the result of a steadily ascending mass of air. After the conditions of supersaturation and of overcooling have been removed, the air still continues its ascent, but condensation takes place directly into snow, and these snow clouds form the so-called cirrus cover. In this way von Bezold explains the temporary rise of pressure, the sudden heavy rainfall so characteristic of thunderstorms, the boiling up of the thunder-heads, and the occurrence of hail at high altitudes, while rain falls in the valleys.

In concluding this short review a few words of comment on the part of the present writer may not be out of place. The classification into heat and cyclonic thunderstorms, first proposed by Mohn and since generally adopted in Europe, does not seem to hold well for the thunderstorms of New England Our thunderstorms occur most frequently in the southern quadrant of cyclonic depressions, in the region of southerly or southwesterly winds, their position showing that they are dependent for

their development not only on the heat of summer afternoons, but also on the warmth imported by the winds. This is further proved by the fact that our most severe storms come in connection with V-shaped depressions and along the line between the warm southerly and the cool northerly winds, where the tendency to instability is greatest. No attempt has yet been made to draw isobars for less than every ten hundredths of an inch in New England, but it is extremely probable, we might say it is certain, that such charts would very often reveal the existence of secondary depressions and of tongues of high pressure, which have been found to be the common accompaniments of thunderstorms in Europe. In the present state of our knowledge of the thunderstorms of New England it seems that they are usually due to a combination of the primary cyclonic circulation and the diurnal warming by the sun's heat, although we also have distinctly anticyclonic thunderstorms, which are directly due to local warming. It appears, therefore, that no sharp line can be drawn in this case, and that our thunderstorms are best classified according to the position in which they occur with reference to the cyclonic centre. In this connection the occurrence of the winter thunderstorms of Germany along the coast and in the night is matched in New England, where our winter thunderstorms are also distinctly nocturnal and coast phenomena.

The effect of topography upon the course of thunderstorms has lately been mentioned in this Journal (Vol. IX., 26–27, 214), in connection with the thunderstorms of New England. In general the dividing of the storms on reaching mountains and their following along the sides of some valleys, instead of passing through them, are noticed both in Germany and New England ; but the accelerating and retarding effects of mountains have not been proved for the storms of the latter region. The question as to whether or not cirrus clouds are essential to the development of this class of storms is an interesting one, and is worthy of careful observation. We have seen, in the first paper of this series (Vol. IX., 538), that Mr. Scott considers cirrus clouds essential to thunderstorm development, while Dr. Reimann, as we have noted above, does not think them necessary accompaniments of thunderstorms in all cases.

The occurrence of thunderstorms below the level of a mountain top, as noted in the observations on the Schneekoppe, does

not seem to be very definitely established in all cases. When an observer is standing on a mountain summit it is by no means easy to determine whether a cloud seen at some distance is below the level of the summit, or above that level. In making this statement it is not intended to imply that no thunderstorms occur below mountain summits, but only to indicate that there is a considerable degree of uncertainty in any such observations. That thunderstorms do occur near the earth's surface, without extending far up into the atmosphere, seems to be an established fact.

Prof. von Bezold's paper presents some new ideas as to the local rise of pressure and the formation and movements of the clouds in thunderstorms. The theory advanced by Ferrel, though not stated by him in writing, that the rise of pressure is due to the reactionary "kick" of the rapidly ascending mass of air, seems to us to give a more adequate explanation than the theory advanced by von Bezold. The different cloud movements to which the latter writer refers are well worth careful examination, for from them we must gain our knowledge of the actual mechanism of a thunderstorm. In this connection we may note that the small rapidly moving clouds described by Dr. Kassner, and referred to in the preceding pages, were evidently of the same kind as those observed by Prof. Davis, at Cambridge, Mass, on June 17, 1892, and described on page 231 of the ninth volume of this JOURNAL.

The following bibliography of the literature on the thunderstorms of Germany from 1890 to the close of 1892, although it is probably incomplete, is presented as a possible aid to other students of the subject:—

1. SCHWEN, G., *Gewitterzuege im nördlichen Theile des Mansfelder Seekreises und des Saalkreises.* Mittheilungen des Vereines für Erdkunde zu Halle, 1889. (Met. Zeitschr., VIII., 1891, 149.)

2. ESCHENHAGEN, —., *Gewitter bei Potsdam am 30 Juni,* 1891. Met. Zeitschr., VIII., 1891, 358.

3. KASSNER, C., *Einige Beobachtungen bei Gewittern.* Met. Zeitschr., VIII., 1891, 391.

4. LANG, C., *Die Fortpflanzungsgeschwindigkeit der Gewitter in Süddeutschland während des Jahres* 1889, *und Zusammenfassung der in den letzten* 11 *Jahren gewonnenen Ergebnisse.* Beobachtungen der meteorologischen Stationen im Koenigreiche Bayern. Band XI., Jahrgang 1889, München, 1890. (Met. Zeitschr., VIII., 1891, 68.)

5. LANG, C., *Die Fortpflanzungsgeschwindigkeit der Gewitter in Süddeutschland*

während des Jahres 1890. Ibid. Band XII., Jahrgang 1890, Muenchen, 1891. (Ibid.)

6. Horn, F., und Tillmann, C., *Beobachtungen über Gewitter in Bayern, Württemberg und Baden während des Jahres* 1889. Ibid., Band XI., Jahrgang 1889, Muenchen, 1890. (Ibid., 74.)

7. Horn, F., und Tillmann, C., *Beobachtungen ueber Gewitter in Bayern, Württemberg und Baden während des Jahres* 1890. Ibid., Band XII., Jahrgang 1890, Muenchen, 1891. (Ibid.)

8. *Die Gewitter des Jahres* 1891, *nach den Beobachtungen in den Fürstlich Lippischen Oberforstereien.* Das Wetter, X., 1892, 116.

9. Von Bezold, W., *Zur Thermodynamik der Atmosphaere. 4te Mittheilung: Uebersaettigung und Ueberkaltung; Gewitterbildung.* Sitzungsbericht der Berliner Akademie für 1892; Met. Zeitschr., IX., 1892, 321; Das Wetter, IX., 1892, 233, 254, 278.

10. Hellmann, G., *Gewitterregen in Berlin am 13ten Juli,* 1892. Met. Zeitschr., IX., 1892, 357.

11. Klimpert, R., *Keine Gewitter mehr, oder, Wie man sich mit einfachen Mitteln vor Allen Blitz- und Gewitterschaden schützen kann. Berlin,* 1891.

12. Heinisch, M., *Beitraege zur Klimatologie von Leobschuetz, II. Gewitterverhaeltnisse.* Program des K. Kath. Gymnasiums zu Leobschuetz, 1892.

13. Tillmann, C., *Beobachtungen ueber Gewitter in Bayern, Württemberg, Baden und Hohenzollern während des Jahres* 1891. Beobachtungen der meteorologischen Stationen im Koenigreiche Bayern. Band XIII., 1891. Muenchen, 1892.

14. Lang, C., *Die Fortpflanzungsgeschwindigkeit der Gewitter in Süddeutschland während des Jahres* 1891. (Ibid.)

15. Erk, F., *Eine Windhose zwischen Gewitterwolken.* Das Wetter, IX., 1892, 262.

16. *Gewitterbeobachtungen im Reichstelegraphengebiet,* 1889–1890. Archiv für Post und Telegraphie. 1892, No. 14.

17. Barthold, —., *Ueber Gewitterschaeden.* Leipzig, 1892.

Nos. 11 to 17 of these articles and reports have not been accessible. Of the others, we have noticed the most important.

Harvard College, June 1, 1893.

MOUNTAINS AS STORM-BREEDERS.

T. W. HARRIS.

THERE is a very prevalent idea, which we find cropping up in literature, poetic and otherwise, at frequent intervals, and which is traceable even back to the times of the ancient Greeks, that storms, and especially thunderstorms, have their seat of origin in mountainous regions.

This idea, like many other popular superstitions concerning natural phenomena, is not without foundation, as the writer had

opportunity to observe during the hot weather of July, 1892, when thunderstorms were of frequent occurrence.

During the latter half of this month, the writer was in charge of a class of geological students, whose work lay in the vicinity of Catskill, N. Y. The town lies in the valley of the Hudson, near the river, about eight miles east of the Catskill Mountains, whose highest summits stand about four thousand feet above the sea; while the Taconic range rises to a somewhat less elevation along the western border of Massachusetts, twenty miles to the east. The heat during most of this time was intense, forcing the class to work almost constantly under the protection of open umbrellas; and as the party gladly welcomed the shadow of every passing cloud, their attention was naturally attracted to the conditions under which clouds might be expected to appear.

The mornings generally began warm and cloudless, except for the slight veil of haze which partially concealed the mountains from view; but by about nine o'clock small wisps of cloud would begin to drift eastward from the region of the Catskill Mountains. As the morning wore on, these would become larger and more numerous; and our eyes would begin to turn westward in expectation of the appearance of masses large enough to afford a temporary relief from the increasing heat of the sun. But these hopes were usually long in being fulfilled; for, as the clouds drifted eastward in the light westerly winds which prevailed almost constantly, they melted away, and it was often full noon before any clouds journeyed far enough eastward to cast any shade at Catskill. They were conspicuously the most numerous over the mountains, and were distinctly fewer and smaller over the lower hills to the north and south. Looking eastward to the Taconic Mountains, a similar belt of clouds might be seen hovering over them, while the sky over the intervening valley remained clear and cloudless.

But by about noon the clouds usually became numerous and thick, and drifted eastward in large numbers, their tops swelling upward in great rounded masses, often so rapidly that their growth could be distinctly followed by the eye, and stretching out eastward far ahead of their bases, as they rose into the swifter currents of the higher atmospheric strata. Their total height must often have been at least five or six times the height of

their bases above the ground, which we estimated by a rough triangulation, based on the angle of elevation of the cloud's bottom, as determined by our clinometers, and the position of its shadow on the ground, observed from a hill top, to have been on an average not less than two miles.

The larger number of the clouds progressed no further in their development, but drifted eastward until they melted away at various points above the valley, depending variously upon the size of the cloud and the time of day. But at times a curtain of rain would appear, trailing from the cloud's base as it drifted eastward. Sometimes this rain curtain was so weak as not to reach the earth, the drops apparently evaporating before falling upon the ground, and was of a very temporary character ; but more generally, those clouds whose development went on to the degree of effecting precipitation, seemed at this point to begin a more rapid increase in volume, and to grow into well marked thunderstorms. This was of almost daily occurrence, and more than once it happened that two or three such small thunderstorms were visible simultaneously. So rapid was the growth of the storm after the rain had once begun to fall, that at times scarcely half an hour elapsed after a good-sized mass of cumulus appeared from behind the Catskills, before its top had swelled upward to a vast height, and the impending rain had driven the party to the nearest barn for shelter.

As a rule, however, these storms were short lived. They usually broke between two and four o'clock in the afternoon, and rarely lasted more than half or three quarters of an hour, before passing away to the eastward.

The most noteworthy feature of these storms was their very evident connection with the mountain mass just to the west of us. Being an elevated region of comparatively small extent, this connection was distinctly traceable. The most numerous and the most violent thunderstorms came from over the mountains ; and storms were distinctly less numerous both to the north and to the south. The connection may be supposed to depend upon the fact that the elevated nature of the mountain mass brings the ground in that region into contact with a portion of the atmosphere which, on account of its greater elevation, is under less pressure than the air next the ground in the adjacent valley. Let us suppose the air to be in the first place

in a condition of equilibrium, so that along any imaginary horizontal surface in the atmosphere, at whatever height it may be located, the barometric pressure is everywhere the same. Such a condition ordinarily prevails in the early morning, when the air, freed from the inequality of conditions that accompanies the presence of the sun's rays, has had opportunity during the night to arrange itself in a stable manner. But soon after sunrise the rays of the sun, falling upon the earth, warm the ground; and this heat is quickly transmitted to the air in contact with it. Now, were the conditions of application of this heat everywhere uniform, no change would result, save a moderate expansion of this lower stratum of the atmosphere. But two sources of disturbance immediately begin to operate. First, the surface of the ground, being uneven instead of horizontal, makes various angles with the direction of the incident rays, and is not everywhere heated alike; just as the different zones of the surface of the globe are unequally turned to the sun's rays and hence are unequally heated, causing the variation in climate between high and low latitudes. So in the Catskills, the eastern, and later in the day, the southern, slopes of the mountains, receive more of the sun's rays than their opposite sides; they become warmer, and the air over them becomes warmer than in the adjacent tracts; and with the greater local heat a greater local expansion of the air occurs. This raises the overlying strata of the air in such areas to a greater height, and into the presence of surrounding masses of air of less density. This enables the raised air to expand laterally, and reduce the amount of air, and hence the pressure over the heated area, while it correspondingly increases the amount of air and the pressure over the adjacent areas; air then flows into the heated area from the adjacent areas along the surface of the ground, and the ordinary phenomena of a convectional circulation result, with the condensation of moisture in the ascending currents, and the formation of clouds and (if the ascent becomes sufficiently high and rapid as the day advances) of rain.

A second source of disturbance is found in the varying heights of the mountains. Upon their summits the air is less dense than it is upon the surrounding lowland, and a given amount of heat-energy, transmitted to it from the ground below, will produce more expansion than upon the air over the lowland,

weighed down as that is by the greater pressure of the thicker overlying column. This greater local expansion, permitted by a less local pressure, will produce the same result as a greater local expansion, caused by a greater local temperature, and similar convectional currents will result. The height and the ruggedness of the mountain region will therefore combine to cause ascending atmospheric currents, with their accompanying clouds and rain. These, as fast as they form, are carried eastward over the valley, and fresh air takes their place upon the mountain summits, to be heated and form new ascending currents in its turn.

But now as the great body of the atmosphere, with its clouds, drifts slowly eastward from the mountains, it descends upon the lowland, just as the water of a stream, flowing over an obstructing rock in its course, descends upon the lower side of the rock into deeper water; and with this descent a condensation of the air takes place; it grows warmer, and its condition ceases to be one of saturation, so that precipitation of moisture ceases and the clouds begin to be reabsorbed and to disappear as they pass to the eastward. But as the day advances the convectional currents become stronger and higher, and the consequent greater condensation is less affected by the descent from mountain to lowland. Moreover, the air over the lowland, which is less easily upset by convectional action, by reason of the more even topography and the greater barometric pressure, than it is over the mountains, becomes in its turn thus affected, and the area of convectional circulation is extended. But with the greater thickness and density of atmosphere affected, a more vigorous convectional upsetting of the air takes place; hence, as the convectional circulation extends itself over the lowland to the east, the convectional currents increase in intensity and height, and the formation of clouds, instead of being checked, goes on more rapidly than before. This may perhaps explain the sudden rush with which the thunderstorms appear to develop, after the cloud formation has passed a certain point.

The area of the Catskill mountains is small, and the connection of these storms with the elevated mass is distinctly traceable; but so far as we could observe, the more detailed topography had no effect upon them. The mountain area is essentially a plateau, intersected by deep, narrow ravines, or

"cloves," which extend in a radial manner outward about its margin. But this topography appeared to have no effect upon the course of the storms. They seemed to originate indifferently over any part of the mountain mass, and to move due east from whatever quarter they formed in.

It was difficult to compare the cloud formation over the Taconics to the east with that over the Catskills, because of the greater distance of the former, and because, also, we were on relatively different sides of the two ranges, with respect to the motion of the clouds ; but the cloud growth, so far as could be seen, appeared to be slower and weaker over the Taconics, which was what might have been expected from the less height of that range.

More detailed observations upon the connection of thunderstorms with topography would be interesting ; and the suggestion may not be amiss that in the observations of thunderstorms to be carried on during the coming summer, under the direction of the Weather Bureau, especial attention should be given to any possible relations that can be traced between such storms and topographic features, such as small mountain masses, like the Catskills or the White Mountains, or the prevailing trend of valleys, as in Central Pennsylvania. Such observations, if carried on systematically, might add materially to our knowledge of the conditions under which storms of this class originate.

THE CLIMATE OF THE INTERIOR OF GREENLAND.*

PROF. H. MOHN.

I HAVE already discussed the results of the meteorological observations, taken during Dr. Nansen's journey across Greenland in 1888, in a memoir published as *Ergänzungsheft*, No. 105, to *Petermanns Mittheilungen*,† and recently I have acquired a knowledge of the results obtained on Lieut. Peary's

* Reprinted from the *Scottish Geographical Magazine* for March, 1893, Vol. IX., pp. 142–145.

† *Wissenschafliche Ergebnisse von Dr. F. Nansen's Durchquerung von Grönland*, 1888. Von Professor H. Mohn und Dr. F. Nansen. Gotha: Justus Perthes, 1892. I. Theil: *Ergebnisse der astronomischen, magnetischen, trigonometrischen und meteorologischen Beobachtungen*, von H. Mohn.

journey over the inland ice of Northern Greenland from the newspapers and the lectures delivered in Christiania by his companion, Mr. Astrup, a Norwegian. From these data it is possible to construct, in general outline, a sketch of the climatic conditions of the interior, which I shall now proceed to delineate.

Greenland is an elevated land covered with eternal snow and ice; only a narrow strip along the coast is free from snow in summer. The highlands of the interior have the form of a shield, sloping steeply to the coasts, but, further inland, inclining gently up towards the centre. On the sixty-fourth parallel, the culminating line lies somewhat nearer to the east coast than the west. Both in the lower and higher latitudes, considerable altitudes are attained. Nansen's highest point was at 8800 feet above sea level, and Mr. Peary found, near the eightieth parallel, elevations of about 8000 feet.

In respect to atmospheric pressure, the interior constitutes an almost permanent anti-cyclonic region. Areas of minimum pressure that pass steadily over the adjacent seas may sometimes extend their limits over the inland ice, but a belt of high pressure is generally left between the cyclones of Baffin's Bay on the one side, and those in the Greenland Sea on the other. It is rare that a centre of minimum pressure passes across Greenland from west to east, as in the case observed by Dr. Nansen, on Sept. 7, 1888, when a strong wind from the southeast was followed, after a short lull, by an equally strong wind from the northwest.

The variations of pressure are less in the interior of Greenland than on the west coast or in Iceland.

In complete accordance with the existence of high pressure in the interior is the observed fact, that the winds over the inland ice blow, as a rule, towards the coasts. During Dr. Nansen's journey, forty-five per cent of the winds on the eastern side blew from the northwest, while on the western side twenty-nine per cent came from the east, and twenty-one per cent from the southeast, the least frequent winds being the northeast on the one side and the west on the other. On Mr. Peary's route, the prevailing wind was from the south.

The observations of Dr. Nansen, and of the Danish meteorological stations on the east coast, show that on the sixty-fourth

parallel the mean annual temperature at an elevation of 6560 feet is about — 13° F., or, reduced to sea level, 5° F. Assuming the mean annual range to be the same as in Lapland, which is certainly not too high an estimate, we arrive at a mean temperature for the warmest month, July, of 14° F., or 32° at sea level. For the coldest month (January ?), the mean, found in the same manner, will be — 40° F., or — 22° reduced to sea level.

From these figures it is evident that it is incorrect to draw the isotherms, as has hitherto been done, due east to west across Greenland. They should be drawn in curves following the outline of the coast, a method fully justified by the more recent observations in other continental countries. If we examine a good set of isothermal charts — those, for instance, of Dr. Julius Hann* or Dr. Buchan — we see that an isothermal line, for the year, of 5° F. must follow the curvature of the coast.

Within this lies the isotherm for 0° F., passing through the interior and the northern parts of Greenland. The isotherm for 14° F. runs from the 72d parallel on the west coast southwards along the seaboard, touching or crossing the long fiords, turns eastward round the south of Greenland, and, following the east coast past Scoresby Sound and over Franz Josef Fiord, reaches the shore at about the 78th parallel, where it passes out to sea.

The isotherm of 32° F. through the central parts of Greenland is easily drawn on Hann's or Buchan's* chart (for July). I have carried it up to the 80th parallel, determining its course from the following reasoning The sun in summer is here circumpolar, but only about noon is it high and powerful enough to check the radiation from the ground, and the highest temperature it can produce is 32° F., its energy being chiefly spent in melting snow. During the night, on the other hand, the sun is so low that radiation from the snow is freely propagated through the rarefied air, and the temperature sinks considerably below the freezing point. The mean temperature of the 24 hours will, therefore, be several degrees below 32°, and only just reach that point when reduced to sea level.

Now, Mr. Peary observed in July, near the 80th parallel and at elevations of about 8,000 feet, temperatures ranging during

**Atlas der Meteorologie* (in *Berghaus' Physikalischer Atlas*, Part III.), Tafel II., Nos. 27, 28, 29. "*Challenger*" *Report — Physics and Chemistry*, Vol. II., Part V.

the day from $26\frac{1}{2}°$ to 32° F., and in the night from 23° to 5°, from which records we obtain a daily mean of about 21°, or, reduced to sea level, 37° to 39°. Consequently the isotherm of 32° at sea level seems not to reach quite as far north as I supposed, but the difference is immaterial.

In the coldest month we find in the interior on the parallel of 64° a mean temperature, reduced to sea level, of —22° F. The corresponding isotherm also runs parallel to the coast, beginning on the 76th parallel on the west, and reaching the 64th in the interior, whence it ascends to lat. 80° on the east coast. We are further warranted in drawing an isotherm for a temperature as low as —40° F. in North Greenland, for the mean for January in the straits between Greenland and America is —31°.

In the month of September, Dr. Nansen experienced during the night temperatures of —49° F., and in the winter Mr. Peary recorded minima below —58°. On board the "Alert" Sir George Nares observed a temperature of —74°. We may, therefore, conclude that in winter the minima are as low as — 76° or even —90°. The interior of Greenland is, indeed, a pole of cold, situated in the opposite longitude to that of Siberia, with which it is well able to compete in extreme severity.

The daily range is very considerable in the interior during the solstices, owing to the great radiation that takes place from, or to, the earth through the highly rarefied atmosphere. In clear, cold weather it sometimes amounts to 40°. Such a range is elsewhere found only in deserts, but the interior of Greenland is really an elevated, snow-covered desert.

The low temperatures and large ranges observed refer only to the lower strata of air immediately above the snow, where the effect of radiation is most powerful. In the higher regions of the atmosphere the downward movement of the air in the centre of the anticyclonic area must render the air warm relatively to the height, and the climate will be less severe than on the snow-clad ground.

The relative humidity in the interior of Greenland is generally rather considerable, the mean being above 90 per cent. *Föhn* winds are not observed here ; they are confined to the valleys on the edge of the inland ice, the fiords, and the coasts.

In the interior of Greenland Dr. Nansen found that the cold-

est wind was the northeast, and the warmest the southwest. On the eastern side the southeast was accompanied by the greatest amount of cloud, and the northwest by the least. On the western side the west and southwest were the cloud-bearing winds, the clearest sky occurring during northeast winds. When the wind blew from the sea there was the greatest probability of precipitation. Thus we see that those coming from the interior were dry winds. Snow fell about every fourth day, and every fourth day the sky was clear; every other day the sky was overcast. Fog was rare.

From the foregoing remarks it will be seen that the climate of Greenland is continental, with large ranges of temperature. The mean temperature for the year is low, and for the winter very low — perhaps the lowest to be found on the globe. In contrast to the climate of other continents the summer temperature is also low, owing to the high latitude, the great elevation, and the vast extent of continuous snow fields. Both in summer and winter the interior of Greenland contains a pole of low temperature, a centre of high atmospheric pressure from which anti-cyclonic winds radiate.

CURRENT NOTES.

The Climate of New South Wales. — A second edition of a pamphlet entitled "Physical Geography and Climate of New South Wales," by Mr. H. C. Russell, F. R. S., Astronomer Royal for New South Wales, has recently been issued at Sydney by authority of the New South Wales Government. The following extracts from this pamphlet were printed in *Nature* for Jan. 12, 1893, and are here reprinted as being of general interest: —

"In works of reference, Australia generally is credited with heat in excess of that due to its latitude. It is difficult to say why, unless it arose from a habit of one of our early explorers who carried a thermometer and carefully published all the high, and none of the low readings he got, until, fortunately for the colony, the thermometer was broken and the unfair register stopped. But not only the interior — Sydney even to the present day is credited, in standard works of reference, with a mean temperature of 66.2°, or more than three degrees higher than the true mean, which is 62.9°. Such an error is not excusable when meteorological observations have been taken and published for just forty years. There is another error made by some writers when describing Australia. It is shown by them inverted on the corresponding latitudes in Europe, and the reader naturally infers that Australia is as hot as those parts of Europe. Confining our attention to New South Wales, that is, between 29° and 37° of south latitude, we find that generally it is cooler than a corresponding part of Europe. The mean temperature of the southern parts of England is about 52°, and that of France, near Paris, about the same, increasing as you go south to 58.5° at Marseilles. Taking this as a sample of the best part of Europe, let us see how the mean temperatures in the colony compare with those: Kiandra, our coldest township, situated on a mountain, is 46°; Cooma, on the high land, 54°; Queanbeyan, high land, 58°; Goulburn, high land, 56°; Armidale and New England district, 56°; Moss Vale, 56°; Kurrajong, 53°; Orange, 55°. These towns are scattered along the high table-lands from south to north, and represent fairly the climate of a very considerable portion of the whole colony. Next to this in point of temperature is the strip of land between the ocean and the mountains, and which is affected by the cooling sea-breezes. Here we have a mean temperature ranging from 62° at Eden, the most southern port, to 68° at Grafton, one of the northern ports. Sydney, in latitude 34°, has a summer temperature only four degrees warmer than Paris, which is in latitude 49°. Now the usual difference for a degree in latitude is a degree in temperature, and therefore, if Sydney were as much warmer than Paris as its latitude alone would lead us to expect, its temperature should be 74°, and that is 15° warmer than Paris; but as we have seen, it is only 4°

warmer. This single example is enough to prove the comparative coolness of our coast districts. The investigation made during recent years shows that the mean temperature of the whole colony, as derived from forty-five stations scattered over it, is 59.5°, three degrees lower than that of Sydney, or only one degree hotter than that of Paris.

"It may be mentioned that the highest shade temperature ever recorded in Sydney was 106.9°, and near Paris a temperature of 106.5° has been recorded.

"The third great district, consisting of lower land and plains to the west of the mountains, has a climate considerably warmer in summer than the parts above described, owing to the powerful effect of the sun on land having little forest and little or no wind; but in winter the temperature sinks down much lower than the coast districts, owing to the great radiation; so that the annual mean temperature is not so great as the summer heats would lead one to anticipate. A table has been prepared for the purpose of showing by comparison with many places in Europe and America the temperature of the colony. The places have been arranged in order of temperature, taking for that purpose the mean annual temperature. This shows at once that the range of temperature here is equivalent to that offered by Europe from the north of England through France to Sicily. Such a range is more remarkable, because if New South Wales were placed on the map of Europe according to its latitude it would extend from Sicily to Cairo, whereas when placed by its temperature it stretches as we have seen from Sicily northwards to England. Nor is this all that the table shows us. For even when we find a place in Europe with a temperature equal to that of some place here, it is at once observed that the summer temperature in Europe is warmer than the colonial one, and the winter colder; for instance, Naples, 60.3°; Eden, 60.3°; summer at Naples, 74.4°; at Eden, 67.9°; winter at Naples, 47.6°; Eden, 51.9°; and so generally the southern country has the cooler and more uniform temperature. It is worthy of remark that the only places here of equal mean and summer temperature with places in Europe are those which are to be found on the western plains, as at Wagga Wagga, which has a mean temperature of 60.3°; Naples, 60.3°; and summer temperature of both is 74°; or again, to compare the places of the same or nearly the same latitude, Messina, in Sicily, latitude, 38° 11′, has a mean temperature of 66°, summer, 72.2°, winter, 55°; Eden, New South Wales, in latitude 37°, has a mean temperature of 60.3°; summer, 67.9°, winter, 51.9°; or Cairo, in latitude 30°, mean of 72°, summer, 85.1°, winter, 58.2°; Grafton, latitude 29° 45′, mean, 68.1°, summer, 76.8°, winter, 58.4°. It is useless to multiply examples, — we have here enough to show how much cooler Australia really is than the fervid imaginations of some writers have made it appear in print.

"Looking at this question of temperature generally, it will be seen that New South Wales is no exception to the general deduction of science that the southern lands are cooler than those of corresponding latitudes in the north, and it is only during hot winds, which are very rare in New South Wales, that the temperature rises to extremes. But to leave Europe, and compare the climate of New South Wales with that of America. Our limits

of latitude would place us from Washington to New Orleans. Now the mean temperature at Washington is 55° and at New Orleans 68°, while that of Eden is 60.3° and Grafton 68.1°; so that if mean temperature were a complete test of climate it would appear that our coast is hotter than corresponding latitudes in America. But mean temperature is not enough; we must compare the summer and winter temperatures; and summer at Washington rises to 76.7°, and at Eden only to 67.9°, 9° cooler; New Orleans summer is 82° and Grafton 76.8°; but 82° hardly represents the summer heat at New Orleans, for it is a steady broil, during which every day for three months of summer the heat is over 80°, a temperature that is only reached on this coast during hot winds, or in other words, very seldom. But winter temperature at Washington falls to 37.8°, and at New Orleans to 56°; at Eden, 51.9°, and at Grafton 58.4°. Hence it is evident that on this coast the heat is very much less in summer and greater in winter than upon the coast of America. Such facts place the colony in a very different position in regard to climate from that which it has occupied in published works, for instead of being a hot country we see that its coast districts are much cooler than corresponding latitudes in Europe and America, and that in its elevated districts, which comprise a large part of it and much of the best land, it has a climate no warmer than the best and most enjoyable parts of Europe in much higher latitudes; but while bringing these facts into due prominence it is not the intention to deny that another considerable part of the colony, forming the western plains, is subject to greater heat, caused no doubt, by the sun's great power on treeless plains, and the almost total absence of cooling winds; yet, although in summer the temperature here frequently rises over 100° and sometimes up to 120°, yet owing to the cold at night and in winter, the mean temperatures are not greater than those of corresponding latitudes in the northern hemisphere; and this part of the colony being remarkably dry, the great heat is by no means so enervating as a temperature of 80° in the moist atmosphere of the coast, and, what is of still more importance, it does not produce those terrible diseases which are usually the offspring of hot countries. This is also, no doubt, due to the dryness of the air. Stock of all kinds thrive remarkably well, and are very free from disease in those hot western districts."

The Cold Wave of January, 1893, *at Hongkong*. Mr. Everett Hayden sends the following clipping from the Hongkong *Daily Press* of Jan. 23, forwarded to him by Lieut. H. H. Barroll, U. S. N., of the U. S. S. "Marion." The article is by S. B. J. Skertchly, F. G. S., M. A. I. We hope to receive and publish subsequent articles on the same subject.

"The cold wave, whose crest has just passed over Hongkong, but whose influence is still appreciable, merits more than a passing notice, both because it is unparalleled in severity and from its presenting special peculiarities.

"Since our observatory commenced its records in January, 1884, the temperature has never fallen as low as 40° F., the lowest registered being on Feb. 6, 1889, about five o'clock in the morning. By eleven o'clock on that day it had risen to 52°; by five in the afternoon to 58°, and at midnight it was still 51°. The present cold wave, on the other hand, depressed the

temperature to below 32°, and from a temperature of 50° on the 14th at 10 A. M. it sank to 43°, and till the 18th had never risen above 45°, with many hours at or below the freezing point. Rain fell on the 13th, 15th, and 16th, but neither in Hongkong itself nor in the Peak district did any snow fall, though the ground above the 450 foot contour was for two days covered with ice. The summit of Lantao Island, about 3,000 feet high, and some of the higher ranges behind Tai-mo-shan, were capped with true snow, and the contrast between its dead shining whiteness and the soft pearly hue of the ice-clad slopes was clearly brought out in certain states of the light.

"Rumors were afloat of heavy snow falling in Canton and Macao, and vivid tales of astonished natives and of death in snow drifts circulated among both Chinese and Europeans. No snow actually fell in those places, and though all text-book writers on physical geography (I speak as a culprit) have stated from some unknown authority that (I quote my own error as penance), "It has been known to fall at Canton, on the tropic of Cancer; but this is a very exceptional occurrence," I confess to very grave doubts as to whether it is not one of those exceptional occurrences that has still to happen. I wrote that in 1872; I took the statement from Herschel and Bates and Somerville, and I know it was taught us by all the authorities of say thirty years ago, and I never had cause to doubt it till I came to live in the East. Will any one record his experiences? The probabilities of snow ever falling within the tropics at sea level are very remote; though as we have now had the chill privilege of experiencing a freezing temperature in the tropics, we may be justified in thinking it possible.

"But we must remember one fact — one of the facts that make this cold wave so interesting — rain fell during the coldest part of the period, and it fell as rain and not as snow. This would seem to show that the cold air was a comparatively thin tongue, wedged in beneath a warmer atmosphere above. But we must return to this afterwards. As a rule snow will not fall in a country whose winter isotherm (or *isocheimal*) is above 50°, which corresponds roughly with latitude 30°. Now the latitude of Hongkong is 22° 18′, or about 65 miles south of the tropic of Cancer. Canton is about 45 miles north of us, in latitude 23° 07′, or 20 miles south of the tropic. From the published records of the Hongkong Observatory, I calculate the mean temperature of the winter months, December to February, to be 59°, and Canton with a difference of latitude of only 45 miles, certainly has not a difference of mean winter temperature of 7 degrees. Any way we have this fact to go upon, that the lowest temperature recorded at the Observatory failed to turn the rain into snow. A point like this, fortunately, does not depend upon scientific measurement. Everybody can tell when it snows, and none of our old residents have ever seen snow here or in Canton. Old Chinese sampan-men say that about sixty years ago they remember frost something like the present one; but even they do not pretend to speak of snow, of which, indeed, they seem utterly ignorant. The chances are, then, that we must relegate the old text-book statement of snow falling at Canton to the great limbo of exploded myths, and consider that the term sea-level was intercalated as a gloss, when snow was mentioned as having been visible from Canton, or thereabouts.

"The fact that no snow fell even at the Peak is replete with interest. Victoria Peak is 1,818 feet above sea level, and the temperature decreases in January one degree for every 314 feet, so that the temperature in this month is between five and six degrees lower than at the sea level, and as the thermometer stood at freezing point down in the city, it must have been at least as low as 26° at the Peak; indeed, Mr. Denson informs me he recorded 25°. Now no rain could form at this temperature; yet rain fell at the Peak from cloud that was at least 1,000 feet above its summit, where the temperature was lower still. The only inference that can be drawn is that *the rain fell from warmer air above the cold stratum.* In other words, there was, as suggested above, a wedge or tongue of cold air protruded into and beneath the normal warmer air above. In this again the recent cold wave is interesting.

"This leads to the explanation of a very beautiful phenomenon that accompanied the cold wave. No one who visited the hill district on Monday or Tuesday last (Jan. 16 and 18), will ever forget the fairy-like aspect of the vegetation. Every tree, twig, leaf, flower, and blade of grass was enshrined in limpid crystal ice, like fossil forms in amber; wire netting, with its hexagonal interspaces (the hexagon being the form of the ice-crystal) was infilled with transparent feather-edged plates, and on rails and telegraph lines icicles grew upwards in pellucid needles, instead of downwards as pendent cones.

"The reason is clear. The vegetation itself had been chilled to freezing point. The liquid rain falling upon the cold surfaces froze into solid ice; this ice by radiation further chilled the surrounding air, and so as successive drops laved the ice-coated foliage it froze at once instead of dripping to the ground. So the process went on; layer by layer, infinitely thin, nay almost continuous, and where a suitable base was found, a little tubercle of ice would start, each fresh rain drop would add to its tiny stature, till vertical stalagmites of limpid ice grew into a *frise* of incomparable beauty. It was a sight worth revelling in, and one is glad to know photography has recorded Hongkong's finest transformation scene. How rare was the sight can perhaps best be gauged by the fact that the Chinese bought at no mean prices samples of this transient jewellery."

Royal Meteorological Society. — The Monthly Meeting of this Society was held on Wednesday evening, April 19, at the Institution of Civil Engineers, 25 Great George Street, Westminister, Dr. C. Theodore Williams, President, in the chair.

The following papers were read: —

"The Direction of the Wind over the British Isles, 1876-80"; by Mr. F. C. Bayard, F. R. Met. Soc. This is a reduction, on a uniform plan, of the observations made twice a day, mostly at 9 A. M. and 9 P. M., at seventy stations during the lustrum 1876-80; and the results are given in tables of monthly and yearly percentages.

"Notes on Two Photographs of Lightning taken at Sydney Observatory, Dec. 7, 1892"; by Mr. H. C. Russell, F. R. S. These photographs were taken with a one half plate view lens, mounted in a whole plate camera, and as a matter of course, there is some distortion at the edges. Both photo-

graphs show the gas lights in the streets as white specks, the specks being circular in the centre and crescent-shaped in other parts of the plate owing to distortion. The lightning flashes are also distorted. Mr. Russell believes that this distortion may account for the so-called "ribbon" flashes which are seen in many photographs of lightning. He has also made some measurements of the length and distance of the flashes, and of the intensity of the light.

"Notes on Lightning Discharges in the Neighborhood of Bristol, 1892"; by Dr. E. H. Cook. The author gives some particulars concerning two trees in Tyntesfield Park which were struck by lightning, one on June 1, and the other on July 18, and also some notes concerning a flagstaff on the summit of Brandon Hill, which was struck on Oct. 6.

"Constructive Errors in some Hygrometers," by Mr. W. W. Midgley F. R. Met. Soc. The author, in making an investigation into the hygrometrical condition of a number of cotton mills in the Bolton district, found that the mounting of the thermometers and the position of the water receptacle did not by any means conform to the regulations of the Royal Meteorological Society, and were so arranged that they gave the humidity results much too high. The "Cotton Factories Act" of 1889 prescribes the maximum weight of vapor per cubic feet of air at certain temperatures; and the author points out that if the instruments for determining the amount present in the mills have an error of twenty per cent against the interests of the manufacturer, it is necessary that the makers of the mill hygrometers should adopt the Royal Meteorological Society's pattern for the purpose.

The monthly meeting of this society was held on Wednesday evening, May 17, at the Institution of Civil Engineers, 25 Great George Street, Westminster, Dr. C. Theodore Williams, president, in the chair.

The following papers were read: —

1. "Mean Daily Maximum and Minimum Temperature at the Royal Observatory, Greenwich, on the average of the fifty years from 1841 to 1890;" by Mr. W. Ellis, F. R. A. S., F. R. Met. Soc. The author gives tables of the mean maximum and mean minimum temperature of the air on each day of the year, and also tables showing the daily range of temperature and the mean of the daily maximum and minimum values.

2. "Suggestions, from a practical point of view, for a new Classification of Cloud Forms," by Mr. F. Gaster, F. R. Met. Soc. The forms assumed by clouds at different levels and under various conditions have recently received considerable attention from meteorologists. The author, however, does not approve of the nomenclatures and classifications which have been proposed, as, in his opinion, they appear to be little, if any, better than the older ones they were intended to replace. He now proposes a somewhat different classification, arranging the clouds according to altitude under the following headings: (1.) Surface Clouds, or those which appear commonly between the earth's surface and a level of about two thousand feet; (2.) Lower Medium Clouds, including all varieties which usually float at an elevation ranging from two thousand to about ten thousand feet; (3.) Higher Medium Clouds, or those commonly found at altitudes varying from ten thousand to about twenty-two thousand feet; (4.) Highest (or Cirri-

form) Level Clouds, or those at elevations exceeding twenty-two thousand feet. The author gives the names of each variety of cloud included in the classification, together with an account of the principal characteristics of each as far as appearance goes.

(3.) "Notes on Winter," by Mr. A. B. MacDowall, M. A., F. R. Met. Soc. In this paper the author discusses the question of periodicity in winters at Greenwich and Paris, and the relation of summers to winters.

Hodgkins Fund Prizes.—The Smithsonian Institution in Washington has recently issued an elaborate circular relating to the Hodgkins Fund prizes. In October, 1891, Thomas George Hodgkins, of Setauket, N. Y., made a donation to the Institution, the income from a part of which was to be devoted "to the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man." Under this fund the Institution now announces a series of prizes to be awarded on or after July 1, 1894, as follows: 1. A prize of $10,000 for a treatise embodying some new and important discovery in regard to the nature or properties of atmospheric air. These properties may be considered in their bearing upon any or all of the sciences — *e. g.*, not only in regard to meteorology, but in connection with hygiene, or with any department whatever of biological or physical knowledge. 2. A prize of $2,000 for the most satisfactory essay upon: (*a*) The known properties of atmospheric air considered in their relationships to research in every department of natural science, and the importance of a study of the atmosphere considered in view of these relationships. (*b*) The proper direction of future research in connection with the imperfections of our knowledge of atmospheric air, and of the connections of that knowledge with other sciences. 3. A prize of $1,000 for the best popular treatise upon atmospheric air, its properties and relationships (including those to hygiene, physical and mental). This essay need not exceed twenty thousand words in length; it should be written in simple language, and be suitable for publication for popular instruction. 4. A medal, under the name of the Hodgkins Medal of the Smithsonian Institution, will be awarded annually or biennially, for important contributions to our knowledge of the nature and properties of atmospheric air, or for practical applications of our existing knowledge of them to the welfare of mankind. The medal will be of gold.

The treatises may be written in English, French, German or Italian, and must be in the hands of the Secretary of the Smithsonian Institution before July 1, 1894, except those in competition for the first prize, the sending of which may be delayed until Dec. 31, 1894. The papers will be examined by a committee to be appointed as follows: One member by the Secretary of the Smithsonian Institution; one member by the President of the National Academy of Sciences; one by the president, *pro tempore* of the American Association for the Advancement of Science, and the committee will act together with the Secretary of the Smithsonian Institution as member *ex officio*.

Communications in regard to any matters connected with these prizes or the fund, should be sent to S. P. Langley, Secretary of the Smithsonian Institution, Washington, D. C.

Mountain and Valley Winds. — The following is taken from the Bulletin of the New England Weather Service for January, 1893.

"Perhaps your question box may secure me some accounts of a class of winds that I am persuaded must exist at proper times and places in New England, but of which no description has yet been reported. I refer to the nocturnal winds that descend along the deeper valleys by which our highlands are dissected, and emerge on the lowlands as lively breezes. Such winds are well known elsewhere. I have felt them of considerable violence at the mouth of large valleys leading out from high mountains in Montana, where all conditions favor their active development. They begin to blow about sunset and continue all night; while the surrounding district is relatively calm. They are manifestly simply the nocturnal downward drainage of the air that is cooled on the uplands and on the slanting surface of the valley sides, and which therefore runs down hill and discharges itself in concentrated volume and with increased velocity at the valley mouth.

"The Berkshire plateau of Massachusetts should permit the occurrence of such down-stream breezes every clear winter night, when the general winds do not control the movement of the lower atmospheric layers. Particularly when snow lies on the ground and when the weather map shows an anticyclone over us, the cooling of the quiet air on the highlands and valley slopes should cause distinct down-stream breezes in deep valleys such as those of the Deerfield and Westfield rivers. If any of your readers happen to live in these valleys, or near where they open out on the Connecticut river lowland, can they not give us an account of the local winds, and at the same time discover if they are of limited extent by corresponding with their neighbors in the middle of the lowland, some distance from the eastern margin of the highland. The Farmington river in Connecticut is almost equally well placed for this kind of study. The mouth of Miller's river valley, where it opens westward from the plateau that lies east of the Connecticut river lowland, should furnish similar opportunity for observation.

"Questions of this kind seem to me particularly interesting, because their answers enable us to approach more nearly to the facts of nature than when we limit our observations to routine records of instruments at certain fixed hours of the day, and reduce them only by the simple arithmetical process of averaging. Routine records are essential for the determination of the fundamental facts of climatology, but they do not exhaust the variety of record that the intelligent local observer may gather and report, greatly to the advancement of our science."

W. M. Davis.

Harvard College, Dec. 26, 1892.

Currents of Air in Wells.—In connection with our review of Prof. King's report on the "Level and Rate of Movement of Ground Water," which appeared in the April number of this Journal, page 565, it may be interesting to make a note of a correlated phenomenon recently described in *Das Wetter* (Vol. X. No. 3, March, 1893). A correspondent at Sussnick, in Eastern Prussia, writes to the Royal Prussian Meteorological Institute in Berlin, that he has often noticed currents of air blowing into and out from his well. The strength of these currents varies greatly; sometimes for days there is no

movement, and then again the draft of air attains a considerable degree of velocity. It appears, further, from observations of these movements and of the weather, that when the air blows out from the well foul weather is almost sure to follow, and when there is an indraft into the well fair weather will follow.

The explanation of this phenomenon, as given by Dr. Fisher in the same number of *Das Wetter*, is, that the variations of atmosphere are present not only in the free air above the earth's surface, but also in the air beneath the surface, at least for some distance. As the external pressure varies, so the pressure of the air in the soil and upper strata varies. When, therefore, there is a fall of pressure on the surface, there is a tendency for the air to flow into the well below and out from its mouth, and as falling pressure ordinarily precedes cloudy or foul weather, a current of air from the well is a fairly accurate sign of bad weather soon to follow. On the other hand, during high pressure, the air will tend to flow into the well, and from the well into the soil and rock strata in which the well is sunk. High pressure being the usual accompaniment of fair weather, an inflowing current into the well is a good sign that the weather will be fine.

The Foehn Wind in Switzerland. — An interesting account of the foehn wind of Switzerland recently appeared in the "*Neue Zuricher Zeitung*," and is reprinted in *Das Wetter* for April. In connection with Mr. H. M. Ballou's article on the Chinook Wind,* which is the American foehn, a short abstract of this account may be of interest to the readers of this Journal.

The foehn in the valley of the Hasli, in the district about Meiringen, when fully developed, brings terror to the inhabitants. The strength of the wind is so great that it blows off the roofs of houses, uproots large trees, and rolls huge bowlders down the mountain sides. In addition to the fear that comes on every one at such a time, there is a nervous restlessness and worry which takes possession of most people who are exposed to the foehn, and often prostrates them for the time being. During the prevalence of the foehn the bakers in Meiringen are forbidden, under heavy penalties, to bake bread, so that there is often a bread famine for a day or two. No fires of any kind are allowed in any buildings which are not well protected against fire. Smoking on the streets is absolutely prohibited, and watchmen provided with fire-alarm horns constantly patrol the streets. During the night these patrols call out the hours, as in ancient times. In some villages constant patrols are maintained throughout the year, all the male inhabitants being obliged to take their turn at this duty.

In spite of the danger and the discomfort which the foehn brings with it, it is one of the most indispensable elements of the Swiss climate. It is the truest friend of the organic world, which in many districts could not survive without its warm and life-giving blasts. The foehn is the only thing that can break the force of the winter. The sun alone seems powerless to melt the vast fields of snow and ice, but the foehn comes and in a few hours or days melts and evaporates the snow with such rapidity that it has been

* This Journal, Vol. IX., 541–547.

named the "Schneefresser." In spite of the harm it does, the foehn wind is a blessing to Switzerland.

Ozone as a Means of Forecasting the Weather. — In *Ciel et Terre* for March 16, 1893, M. Victor Rops, of Namur, has an article on the subject of weather forecasting based on the quantity of ozone in the atmosphere. The writer has, since 1891, made daily observations of the amount of ozone in the atmosphere at Namur, and his conclusions are of considerable interest to meteorologists. He finds that if, after a period of several days of fine weather, during which there has been no record of ozone, there begin to be signs of ozone, rain will follow in a short time, and if the amount of ozone increases still further, storms or gales will follow. The termination of the stormy period is preceded by a diminution of ozone. M. Rops believes that weather forecasts may be much improved by constant attention to the variations in the amount of ozone in the atmosphere.

Our present forecasts are, as is well known, not all that could be desired, and any further means of improving them should be carefully investigated. Hitherto the observations of ozone have been more or less unreliable, and of no particular benefit to the general public, but in the line suggested by M. Rops there is presented a most attractive subject for research.

Severe Hail-Storms in New South Wales. — In a paper by Mr. H. C. Russell, F. R. S., read before the Royal Society of New South Wales on Nov. 2, 1892, and reprinted in *Nature* for April 13, 1893, the writer gives an account of some remarkably severe hail-storms which occurred in New South Wales on Oct. 13, 1892. At Tulcumbah Station the observer reported as follows: "I measured some of the hail-stones, six and a half inches in circumference; this was fifteen or twenty minutes after the storm, and I think I did not get the largest. Next morning I found that nineteen sheep had been killed by the hail; also birds, kangaroo-rats, and other animals were found lying dead in all directions. All the windows exposed to the storm were broken, and the galvanized iron roofing is dented from end to end, and many sheets cut through; in several cases the hail-stones went through the iron; in one sheet I found thirty holes, and in another more than sixty." At Avondale the hail was four to six inches deep, and the whole country looked as if a snow-storm had passed over it. Trees in the track of the hail were denuded of leaves and bark. The width of the hail track was a mile to a mile and a half.

Seven-Day Thunderstorm Periods. — In the April number of *Das Wetter*, Dr. Kassner, assistant in the Prussian Meteorological Institute at Berlin, has an article on weekly periods of thunderstorms. His data include the thunderstorm records of fifty-six years, and by averaging these according to days of the week for various periods of ten and more years, he finds that there is a preponderance on Saturdays, with a second maximum on Tuesdays and a minimum on Sundays. His table is as follows: —

YEARLY PERIODS IN PER CENTS.

	Monday.	Tuesday.	Wednesday.	Thursday.	Friday.	Saturday.	Sunday.
1830–40	15.9	14.3	16.7	7.1	8.7	20.6	16.7
1851–70	14.4	16.3	8.9	14.0	14.4	17.1	13.0
1871–90	12.4	13.4	18.2	16.3	12.1	17.0	10.7
1851–80	13.3	15.4	13.5	14.2	15.1	16.7	11.7
1851–90	13.4	14.8	13.7	15.2	14.2	17.0	11.8
1848–92	12.9	15.3	14.0	15.6	14.2	16.0	12.0
1830–40 } 1848–92 }	13.3	15.2	14.4	14.3	13.3	16.7	12.7

Dr. Kassner believes that this periodicity is due to the varying amounts of smoke coming from the factory chimneys on different days of the week.

Pink Snow in Nebraska. — Mr. G. B. Mair, observer of the Nebraska Weather Service at Callaway, Neb., reports in the Weather Service Bulletin of that State for March an interesting phenomenon noticed during a snowstorm at his station on March 7. The first inch of snow fell with an east wind and was of the usual whiteness. The wind then changed to the west and about two inches of snow fell of a decidedly pink color, after which another shift of wind to the east brought more white snow. The pink snow was found to be colored by fine particles of soil, which were evidently carried from the mountains lying to the west by the west wind.

The occurrence of red snow in Greenland has frequently been described by travellers in that region, the color there being due to the presence of minute animals on the snow. Green snow has been reported in Iceland and in Siberia.

CORRESPONDENCE.

HIGH ALTITUDE OBSERVATIONS.

Editor of the American Meteorological Journal:—

The area of low barometer as indicated by the isobaric lines upon the weather map is not, as usually termed, the storm's centre. The storms centre of power is usually found some distance in advance of this point and about four thousand to six thousand feet above the earth's surface. The progressive movement of the lower air strata is retarded by friction upon the earth.

Judging from the influence of topography upon the movements of storms, we conclude that they extend to an elevation of five thousand to eight thousand feet. If they extended to a greater elevation their courses would not be affected by mountains. As it is, only the severer storms are enabled to pass the barriers of our loftier mountain ranges. Those from the Pacific usually pass to the north or south of the Rocky Mountains, and those crossing the lower Mississippi valley are deflected by the Appalachian Range. Longitude 89, latitude 33, which is the southwest terminating point of the last-named range, is of considerable account in weather forecasting for States lying to the eastward. Storms almost invariably pass north or south of the range according as they pass the eighty-ninth meridian north or south of the thirty-third parallel.

These influences of topography indicate the altitudes of centres of power of storms (that part of storms upon the conditions surrounding and accompanying which largely depends the state of the weather upon the surface of the earth), and show the importance of high altitude observations to the intelligent forecasting of weather changes. The intimate connection between conditions of the higher atmosphere and lower atmospheric phenomena is plainly indicated in various ways. Thus weather changes are indicated by the character and movements of clouds; the courses of storms follow pretty closely the mean direction of the upper clouds; and there is a correspondence between their lateral velocities and the velocities of the upper currents. A knowledge of the velocities, humidities, dew-points, directions, and temperatures of upper currents would, therefore, aid much in weather prediction. Such information cannot be obtained from observations taken upon the earth's surface except when taken upon high and comparatively isolated mountain peaks. Even the rainband of the spectroscope, while indicating the presence of excessive moisture in the air, does not indicate the strata in which it is found. The only satisfactory observations are, therefore, those

taken at high altitudes, and may be taken from balloons or mountain peaks. Owing to the unequal distribution of suitable elevations for the latter method it could be made to cover only a part of the field. The States in which such stations might be operated are perhaps as follows: Massachusetts, Maine, Vermont, New Hampshire, New York, Pennsylvania, Virginia, North Carolina, South Carolina, Georgia, Alabama, Kentucky, Michigan, Arkansas South Dakota, Colorado, New Mexico, Arizona, Nevada, Utah, Idaho, Montana, Wyoming, Washington, Oregon, and California. These States have elevations ranging from two thousand five hundred feet to fifteen thousand feet. California is said to have about one hundred points of ten thousand feet elevation. Perhaps less than one half of these points are accessible or suited for places of observation. In localities not covered by such stations, captive balloons would necessarily have to be employed. The danger attending balloon ascensions renders necessary the use of specially devised self-registering instruments which do not require the presence of an observer. Among those best suited, perhaps, are Richard Brothers barograph and thermograph, which could be slightly altered to reduce their size and weight. I should think a thermograph could be constructed to serve the purpose of a wet thermometer — the bulb being kept under the constant influence of evaporation. A Cator's pressure anemometer with a few improvements, and the addition of a self-registering apparatus would serve as anemometer and anemograph. It would not be necessary to have these instruments record for more than thirty minutes or one hour at a time, hence they could be so placed as to record upon one sheet of paper and thus require but one clock. The chief difficulty encountered would be in obtaining a correct record of the wind direction, because of the frequent motions of the balloon, but this could be overcome in the following manner. A compass should be placed near the base of the wind-vane rod and have suspended over it an arrow which by a mechanical arrangement could be readily attached to or detached from the vane rod, and which when attached would revolve with the vane. A lever having two arms and operated by the clock, should have one arm passing into the compass and the other in contact with the arrow suspended above, so that a movement of the lever by the clock at a given hour (the hour of observation), would simultaneously release the arrow from the vane rod and render the magnetic needle immovable. These being thus rendered fixed, would by their relative positions indicate the wind direction at the time of observation. Observations taken in this manner would not be absoluteiy correct, but would doubtless answer their purpose and prove an important help in weather forecasting.

W. J. Wambaugh.

Augusta, Ga. April 26, 1893.

SEA BREEZES AT PROVINCETOWN, MASS.

The Editor of the American Meteorological Journal:

Winds blowing from any direction may be properly said to be sea breezes at Provincetown, for the place is of small area (about four square miles), and nearly surrounded by a large body of water, at a distance of some twenty miles from the mainland. The writer had for some time doubted whether the sea and land breezes of the mainland or the remainder of the Cape, which is much larger in area, extended to Provincetown, having read that these breezes only extend a short distance from the shore line. Without the keeping of records it is difficult to tell whether these breezes are felt at Provincetown or not; so to ascertain, if possible, I in 1888 kept a careful record of the wind directions for three months, at the hours of 7 A. M., 2 and 9 P. M., from June 5 to Sept. 1, and find the result to be as follows: —

PER CENT OF FREQUENCY OF WIND DIRECTIONS.

N	NNE	NE	ENE	E	ESE
.04+	.02+	.04+	.01+	.05+	.01+
SE	SSE	S	SSW	SW	WSW
.07+	.02+	.07+	.06+	.29+	.03+
W	WNW	NW	NNW	Calm.	
.07+	.04+	.10+	.00+	.07+ = .92+	

DIRECTIONS THAT PREVAILED AT THE OBSERVATION HOURS.

7 A. M. — N, NE, ENE, SSE, SSW, WSW, W, WNW, NW.

2 P. M. — NNE, E, ESE, SE, S, NNW.

9 P. M. — SW, calm.

JOHN R. SMITH.

PROVINCETOWN, MASS.

BIBLIOGRAPHICAL NOTES.

THE MOON'S FACE.

G. K. GILBERT. *The Moon's Face; A Study of the Origin of its Features.* Philosophical Society of Washington Bulletin, Vol. XII., pp. 241–292, pl. 3, 8vo, Washington, 1893.

The recent contribution to the Bulletins of the Philosophical Society of Washington, by G. K. Gilbert, entitled The Moon's Face, a Study of the Origin of its Features, although more strictly geographical than meteorological in its nature, yet seems of sufficient interest to meteorologists to be noted in this JOURNAL.

Considering, as it does, in an entirely new light, the physical characters of our own satellite, it opens up anew the question of the atmospheric conditions of the moon. Mr. Gilbert gives us in this paper a unique and most interesting theory for the origin of the physical features of the moon, based not only on an examination of the moon itself but also on a careful study of volcanic phenomena on the earth. Taking up the study from the topographical side, Mr. Gilbert, from his intimate knowledge of geographic form, is peculiarly well fitted for the task he has undertaken. He has also been able to strengthen his argument greatly by the results obtained from a series of experiments, in which he imitated, as well as he could, the conditions of the moon's surface as it must have been when the craters were formed.

The paper opens with a careful account of the surface features of the moon and a detailed comparison with the earth craters, both of the Vesuvian and Hawaiian type. It is found that the dissimilarities are greater than the similarities, and that no theory accounting for the features of the moon as the result of simple volcanic action will explain more than half the craters on the face of the moon exposed to our view. Some other theory must be introduced to account for the rest. The supposition that the craters are the result of tidal action, when the moon had a liquid interior, or as the result of snow and ice accumulations, is also found untenable.

The writer therefore being driven to some theory depending on the action of meteors, develops with extreme care and minuteness his "moonlet" hypothesis; and this is where he departs radically from the paths pursued by previous selenologists. Every meteoric theory tries to account for the moon craters as the result of the impact of projectiles from without, either from tellurean volcanoes, from meteorites or from some other extraneous source. Mr. Gilbert considers the scars as due to the impact of moonlets

which originally revolved around the moon, and with the moon around the earth, and have been gradually drawn into the moon by gravitative force, He traces the development of the earth from an original nebulous condition. through the Saturnian stage and other later changes to the form that it has at present. He supposes that the ring as it existed when the earth was in the present condition of Saturn, broke up into moonlets, and that the largest moonlet, our Moon, gradually attracted all the other fragments to itself. The size and shape of the craters formed by the impacts of the moonlets with the moon vary with the size of the projectiles and the distance from which they came. Furthermore, the writer goes on to show why the larger number of the moonlets, according to this hypothesis, would strike the moon in a nearly perpendicular direction, and hence why the greater number of the scars are nearly round rather than elliptical. A further, but by no means an illegitimate enlargement, of the hypothesis accounts for the immense plain of the Mare Imbrium, the great white streaks which radiate from many of the larger craters, the furrowing and the sculpturing of the craters, the softening of the configuration of the moon's surface in many localities, and many other important and as yet inadequately explained features of the moon. Indeed the Mare Imbrium seems to be the point of impact of the largest moonlet, which melted the rocks around the centre of concussion and sent a flood of lava flowing and splashing in all directions.

In his summary the author states, "The impact theory applies a single process to the entire series (excepting only the rill pits), correlating size variation with form variation in a rational way. Specialized by the assumption of an antecedent ring of moonlets, it accounts also for the great size of many craters. It brings to light the history of a great cataclysm, whose results include the remodeling of vast areas, the flooding of crater cups, the formation of irregular maria, and the convertion of mere cracks to rills with flat bottoms. It explains the straight valleys and the white streaks. In fine it unites and organizes as a rational and coherent whole the varied strange appearances, whose assemblage on our neighbor's face can not have been fortuitous."

The communication is not only worthy of notice because of its originality but also because of the splendid manner in which the theory is presented. Rarely have we seen a better or more logical argument in any scientific communication. The reader is carried along step by step until the whole theory is before him, and he feels its strength to such a degree that he is tempted to adopt it at once without further question. The theory will undoubtedly cause the astronomers to study the moon in an entirely new light, and will probably open up the discussion of the origin of the moon's surface features anew. Though the theory may not be immediately adopted as a true one by the selenologists, yet we feel that the author has struck the right chord in his explanation and that it will not be long before the moon's features are fully explained by this theory or one closely akin to it.

R. E. D.

THE CLIMATOLOGY OF THE COTTON PLANT.

P. H. Mell, Ph. D. *Report on the Climatology of the Cotton Plant.* United States Department of Agriculture, Weather Bureau, Bulletin No. 8, 8vo, pp. 68; charts VII., Washington, 1893.

The writer of this report is well fitted for the work he has here undertaken, being professor of geology and botany in the Alabama Polytechnic Institute, as well as director of the Alabama Weather Service. This Bulletin presents some of the most important results he has brought together after a study of some years. Much of the report is of course interesting chiefly to botanists and to the cotton raisers of the South, but the sections devoted to the History of the Cotton Plant and its Species, and to the General Discussion of those Countries where Cotton is cultivated to any Extent, contain many facts of general interest. The remaining sections deal with the General Climatic Features in the Southern United States during the Preparation of the Land for the Planting of the Seed; The Climate of the Seed-Planting Season; the Growing Period of the Plant and its Weather Conditions; Character of Weather best suited for the Production of Fiber during its Process of Formation, the Picking Season and its Weather, and Comments on Years of Good and Poor Crops. From the character of these headings it will be seen that Dr. Mell has covered the ground of his subject well. "The cotton plant," the author says, "loves the sun, and during its entire life must have an extra quantity of warm rays. It thrives best in that climate where the atmosphere is well-warmed by the almost vertical rays of the sun. In discussing the temperature phase of this subject this fact must be well borne in mind. Observation extended over a wide field of experience has proven this proposition to be indisputable. Seven months from the planting of the seeds until the picking is about completed, are required for the full and satisfactory development of the cotton in all its functions. These seven months must contain a large share of sunshine and be free from heavy frosts. On an average, in the middle section of the cotton belt, forty-six days out of one hundred produce cloudy weather, while fifty-four days are entirely clear. Thirty-two days in one hundred throughout the middle portion of the belt are likely to produce rain during the spring of the year."

The report contains numerous tables and charts. The latter show clearly the uniform temperature which prevails during the three months of summer. In June the mean temperature ranges between 81° and 76°; in July between 83° and 78°, and in August between 81.5° and 78.5°. The mean maxima and minima are never great extremes.

The report as a whole, while not of so general an interest as some of the preceding bulletins have been, is a valuable contribution to a subject which is of very great importance in the southern section of the United States.

SMITHSONIAN METEOROLOGICAL TABLES.

Smithsonian Meteorological Tables. Based on Guyot's Meteorological and Physical Tables. Smithsonian Miscellaneous Collections, 844. Washington, 1893. 8vo, pages i-lix, 262.

The first edition of these tables was compiled by Dr. Arnold Guyot, and published in 1852, at the request of Prof. Henry, as a volume of the "Smithsonian Miscellaneous Collections." Other editions were published in 1857, 1859, and in 1884. The last edition being exhausted in a few years, Prof. Langley, the present Secretary of the Smithsonian Institution, decided to publish a new set of the tables in three parts, consisting of the meteorological, geographical, and physical tables. The present volume contains the meteorological tables, and, although historically related to Guyot's tables, the work is essentially a new publication. In its preparation, the advantage of conformity with the International tables has been kept in view, and so far as consistent with other decisions, the constants and methods there employed have been followed. In the preparation of this work Prof. Wm. Libbey, Jr., and Mr. George E. Curtis have done a great deal of valuable work, Prof. Libbey having revised the tables of the preceding edition, and Mr. Curtis having had the direction of a large amount of computation, and having prepared the whole manuscript and carried it through the press. To Mr. Curtis's interest the present volume is largely due.

The volume is one of very great value to all working meteorologists, and indeed to all persons in any way interested in meteorology. An introduction by Mr. Curtis gives a general description of the tables and of their use. The usefulness of this publication will at once be apparent to those who are not already acquainted with the previous editions by a glance at the subjects of some of the tables, *e. g.*, conversion of Fahrenheit into Centigrade and Centigrade into Fahrenheit; reduction of barometer to sea level; determination of heights by the barometer; conversion of meters per second into miles per hour, etc. A useful list is also given of the meteorological stations of the world, with their latitude and longitude, and their height above the sea in feet and in meters.

TITLES OF RECENT PUBLICATIONS.

CHISTONI, CIRO. *Magnetometro unifilare dei seni. Pubbl. del R. Osservatorio di Modena N.* 1. Fol. Modena, 1893. 24 pp. 4 pl. Extract from: Mem. della R. accad. di sci. Modena, vol. ix. p. 126 et seq.

CLEMENTS, HUGH. *Weather prediction No. 2; or, the mistakes of the Greenwich observers and the Washington International Meteorological Conference.* 12mo. Lond, n. d. (1893.)

HELLMANN, G. *Das älteste Berliner Wetter-Buch* 1700-1701 *von Gottfried Kirch und seiner Frau Maria Margaretha geb. Winkelmann.* 8vo. Berl., 1893. 42 pp.

HEPITES, STEFAN C. *Resumé des observations météorologiques de Bucarest pour l'année* 1890 *et pour la période de* 1885 *à* 1890. Fol. Bucuresti, 1893. 20 pp. Extract from: Anneles de l'Institut Météorol. de Roumanie. vi., 1890.

LIVERPOOL. MERSEY DOCKS AND HARBOUR BOARD. *Meteorological results, deduced from observations taken at the Liverpool Observatory during the years* 1889–91. 8vo. Liverpool, 1893. 77 pp. 3 tab. (Contains mean hourly values of pressure and rainfall for twenty years, 1868–1887.)

MADAGASCAR. OBSERVATOIRE ROYAL. *Observations météorologiques faites à Tananarive par le R. P. E. Colin, S. J.* iii. vol. 1891. 8vo. Tananarive, 1892. 284 p. (Contains hourly records of the principal meteorological elements; also table of mean monthly atmospheric pressure and temperature for sixteen years.)

MADRID. INSTITUTO CENTRAL METEOROLOGICO. *Boletin.* (Daily.) Año 1, 1893. 12 in. x 17 in. Madrid. (First issue March 1.)

MAGDEBURG. *Jahrbuch der meteorologischen Beobachtungen der Wetterwarte der Magdeburgischen Zeitung.* Hrsg. von A. W. Grützmacher. Band x. Jahrgang xi. 1891. 4to. Magdeburg, 1891. 54 p.

PRAG. TECHNISCHES BUREAU DES LANDESCULTURRATHES FÜR DAS KÖNIGREICH BÖHMEN. *Die Einrichtung des Wasserstands-Prognosendienstes an der Elbe in Böhmen.* (Text in German and Czech languages.) Fol. Prag., 1892. 40 pp. 2 pl.

—— *Ergebnisse der Wasserstandsbeobachtungen an den Flüssen Böhmens für das Jahr* 1891. (Text in German and Czech languages.) Fol. Prag, 1892. 62 pp. 6 ch.

—— *Ergebnisse der ombrometrischen Beobachtungen in Böhmen für das Jahr* 1891. (Text in German and Czech languages.) Fol. Prag, 1892. lxii. and 144 pp. 1 ch.

RIPOSTO. OSSERVATORIO METEOROLOGICO DEL R. ISTITUTO NAUTICO DI RIPOSTO. *Bollettino mensile* (January to December, 1892.) Fol. Riposto, 1892.

ROMA. UFFICIO CENTRALE METEOROLOGICO E GEODINAMICO ITALIANO. *Annali. Serie seconda.* Vol. xi. Partes i.–iii., 1889. Fol. Roma, 1892–3.

CONTENTS.

Parte i.

Risultati di un biennio di osservazioni biorarie dell' igrometro registratore Richard. DOMENICO RAGONA.

Valori, normali ed andamento diurno ed annuo della temperatura di Roma. A. CANCANI.

Osservazioni dei temporali raccolte nel 1887. ETTORE FERRARI.

Appendice ai dati desunti dalle cartoline d'osservazione. Fenomeni degul di menzione che accompagnarono i temporali. ETTORE FERRARI.

Parte ii.

Osservazioni meteoriche fatte in Italia nel 1889.

Osservazioni delle stazioni termo-udometriche nel 1889.

UNITED STATES WEATHER BUREAU. *Report on the climatology of the cotton plant.* By P. H. MELL, Ph.D. Bulletin, No. 8. 8vo. Wash., D. C., 1893. 68 pp. 1 ch.

UTRECHT. KÖN. NED. METEOR. INSTITUUT. *Onweders in Nederland naar vrijwillige waarnemingen in* 1891. Deel xii. 8vo. Utrecht, 1892. 174 pp. 4 pl. (pp. 135–174 Uitkomsten van onweerswaarnemingen te Utrecht van 1760–1810 en 1849–1891 en in Nederland van 1882–1891.)